EXHIBIT E

Provisional Patent Application
by
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for

A Particle Deposition System with Enhanced Speed and Diameter Accuracy

I. Background--Field of Invention

This invention is a method for depositing small particles on substrates quickly and cleanly.

II. Background--Brief Description of Prior Art

Particle scanners are used to detect contamination on the surfaces of semiconductor wafers, computer disks, flat panel display glass or other industrial substrates that may be sensitive to contamination. The scanners operate by sensing scattered light from particles as a laser is scanned over the substrate surface. Particles of well-known size are needed to calibrate industry particle scanners. This is accomplished by depositing polystyrene latex (PSL) spheres on a typical surface and using the resulting scanner measurements for calibration. The manufacture of these particle standards depends on a deposition system. It is important that the deposition standards be of known particle size, known particle diameter distribution, and known particle count. In addition, the depositions must be manufactured in a cost-effective manner and the process must not introduce other contamination onto the sample surface. Although the rest of this document refers to the samples as wafers, because most of the current activity is in the semiconductor industry, it is clear that the deposition techniques described are applicable to many different types of deposition substrates.

Basic deposition techniques have been available in the open literature for several years. See for example:

1. "Particle Deposition on Semiconductor Wafers," by B. Y. H. Liu and K. H. Ahn, *Aerosol Science and Technology* 6:215-224 (1987).
2. "Experimental Study of Particle Deposition on Semiconductor Wafers," *Aerosol Science and Technology* 12:795-804 (1990).
3. US Patent # 5,534,309 "Method and Apparatus for Depositing Particles on Surfaces" by Benjamin Y. H. Liu assigned to MSP Corporation

In general these techniques consist of atomizing a suspension of particles in clean water (or other fluid) to form a spray in a flow of clean air. After the particles dry, they are led directly to the sample, or may pass through any of several devices, to control and/or monitor flow rates, and electrically charge or discharge the particles. One common technique is to pass the particle flow through a differential mobility analyzer (DMA), which passes only a selected band of charged particle diameters through a narrow slit. An electric field draws the charged particles sideways through the airflow towards the slit. The smaller particles are drawn through the airflow more easily and reach the slit wall first. Adjusting the electric field allows selection of the particle diameter that passes the slit. Exact control of this process, which depends on temperature and flow parameters in the system as well as the voltage controlling the electric field, has become more important as industry requires better knowledge of true particle size in the deposition. Operational details and further explanation may be found in Appendix A of this document.

III. Current Industrial Practice and Issues

The previously referenced patent employs (requires) a deposition chamber purging step before the wafer is introduced and then again at the end of a deposition after the wafer is removed. This requires that the wafer be removed at the end of each deposition, and because, by this technique, the deposition chamber is sealed, the process of removal slows the manufacture of standards. Currently available systems do not adequately monitor all of the parameters needed to produce long term control of the DMA. The result is unwanted variation in the relationship between particle diameter (passing the DMA slit) and the applied control voltage.

IV. Description of the Proposed Processes

A total of six innovations are listed below. Three involve the manner in which particle flow to the sample deposition chamber is ended and how the system (but not the deposition chamber) is purged. These techniques are used near the output of the deposition process, and are unique in that they all reduce to zero the flow into the deposition chamber at the end of deposition. This has the advantages that the wafer does not have to be removed between depositions, and particles left in the system are not dumped into the deposition chamber during system purging. As a result, the deposition chamber does not have to be purged using this technique. The advantage is faster operation. The fourth innovation relates to the use of airflow within a special deposition chamber used for deposition of particles too large to be conveniently filtered through a DMA. The fifth one relates to a user interface method for controlling the deposition process. The last innovation relates to the insertion of pressure monitors so that accurate, long term, particle sizing and particle count can be achieved through automatic control from the system computer. Refer to Figure 1.

1. See location 1 in Figure 1. Rather than removing the wafer and then purging the system into the deposition chamber with clean air this method leaves the wafer in the deposition chamber and draws the system mixture of air and particles into a vacuum line. One version of this technique simply has the vacuum line capable of drawing more air than the system can deliver. The drawback to this technique is that it will then draw the excess from the deposition chamber. This holds the danger that contamination may be draw into the chamber from outside the system and end upon the wafer. The preferred method uses an orifice in the vacuum line that limits flow to an amount just larger than that delivered by the system.
2. See location 2 in Figure 1. This is similar to 1 above except now a three way valve is sued to isolate the deposition chamber and shunt the system air (during system purge) to a filter.
3. The third technique uses the air/particle mixture drawn into the particle counter (CNC) at location 3a to zero the flow into the deposition chamber. This flow is kept at a fixed value; however, by reducing the clean air flow at 3b the total flow towards the chamber can be made just smaller than the flow drawn by the CNC and there is nothing left to go into the deposition chamber. The system is purged through the CNC.
4. The fourth technique is for use in the deposition of relatively large particles that cannot be (size) filtered with a DMA. These are often deposited on large sample areas by simply atomizing particles above the sample and allowing the particles to fall towards the sample. This process can be aided by running an accessory to draw clean air flow continuously into the chamber towards the sample. It is easily accomplished by drawing air into the chamber through small fans located below the sample. The air is pulled into the chamber through filters located near the atomizer outlet. The atomized particles are terminated when the desired particle count is achieved.
5. The fifth technique involves the of a single computer screen to control the deposition process. This is opposed to the older technique of writing, saving and retrieving recipes that list the critical deposition parameters (count, diameter, etc.). In this technique, the desired count and size are entered and as the deposition proceeds the particle count can be monitored. As a result the deposition process can be paused, or terminated, by the operator with a click of a computer key. The entire process of running the system is much faster using this interface technique. A review of this technique is given in Appendix A.
6. The sixth technique involves the insertion of pressure sensors at locations 4a and 4b to achieve automatic feedback control of deposited particle diameter and particle count. The total flow into the DMA is the sum of the flows at 4a and 5a. The relatively large flow at 5a is kept matched to the flow at 5b. The total flow through the DMA determines the relationship between the particle diameter passing the DMA slit and the applied DMA voltage. The flow to the DMA is temperature sensitive. Therefore, the system utilizes thermistors to monitor gas temperature. Because evaporation is a cooling process temperatures changes over time can be expected caused by the process of drying the atomizer spray. By monitoring the pressure drop across the 4a orifice, the flow rate can be calculated, and then the computer can appropriately change the DMA voltage so that the passed particle diameter remains

constant. [A less preferred method would be to adjust the 5a and 5b flows to keep the total DMA flow a constant; however, this technique is not as sensitive because of the relatively large size of these flows.] When the flow at 4a changes, the flow at 4b will change, because the 5a and 5b flows are held constant. The CNC particle counter at 3b requires a fixed flow rate to be accurate. By sensing the pressure across 4b, the computer can determine this flow and then automatically adjust the flow at 3b so that the CNC gives an accurate count. The result is that both particle diameter and particle count are automatically held to their intended values even when there are variations in the input particle flow. This offers a dramatic advantage in control of deposition parameters over presently available systems.

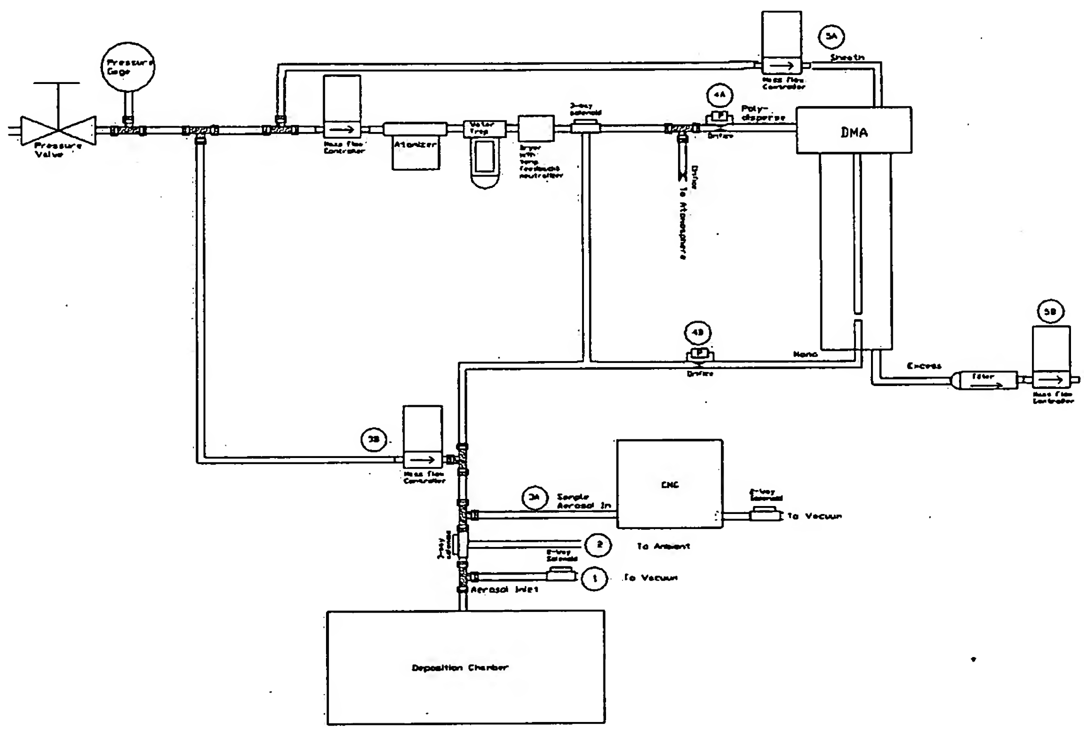
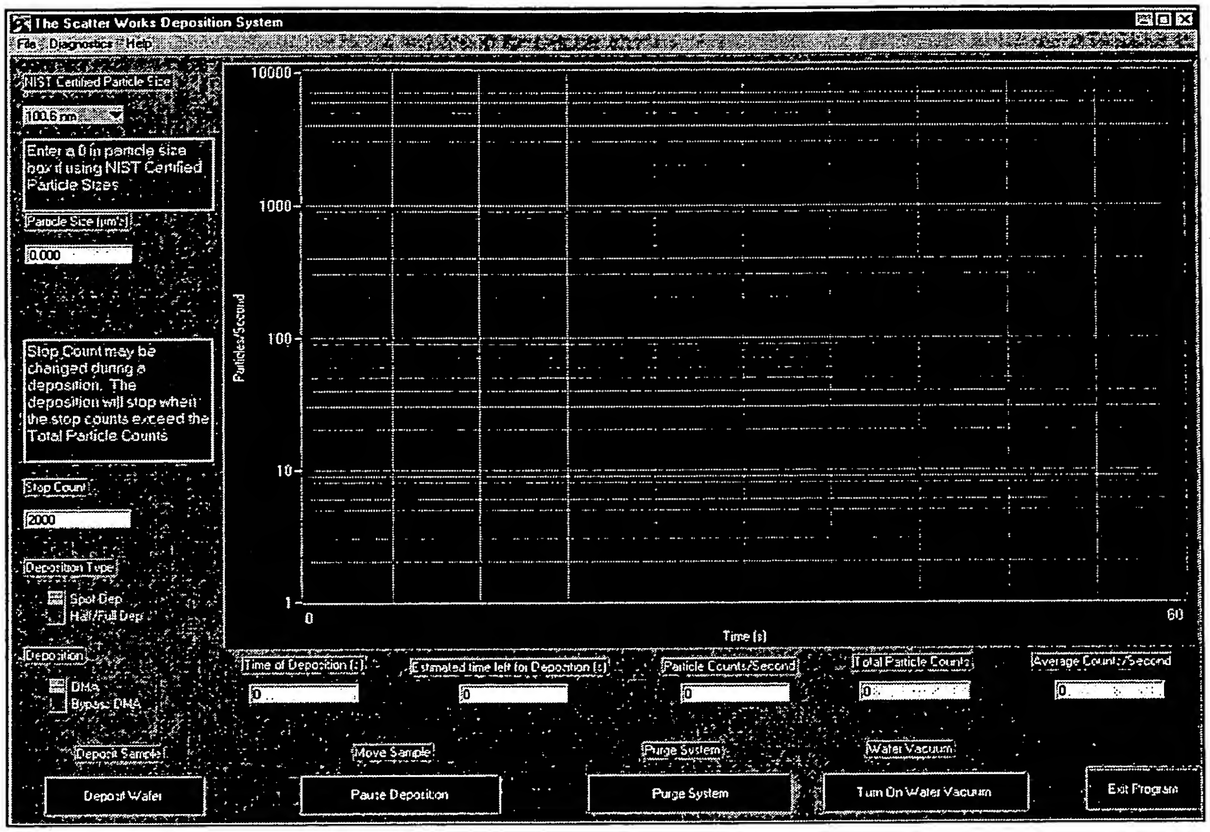


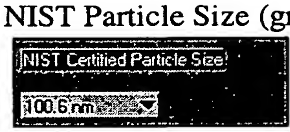
Figure 1. A preferred version of the invention

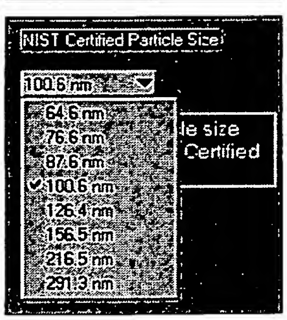
Appendix A. Main M nu Screen Features and General Operation

Main Deposition Screen – The screen shown below is the main deposition screen. The deposition sequence is automatically completed from this screen. In the rest of this section, each of the boxes and buttons are explained in detail. All of the system operation is done from this screen making the system very easy to use.

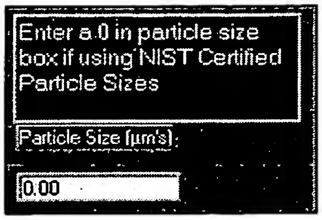


NIST Particle Size (grayed out during deposition) – Press the down arrow on the button to bring up a list of TSW NIST Certified Particle Sizes (make sure a 0 is entered in the particle size box to use the NIST particle sizes). The program will use the particle size and automatically calculate and set the appropriate DMA voltages and flow rates.





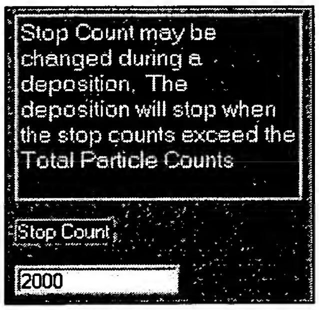
Particle Size Window – Enter a particle size in µm's. By entering a non-zero value in the box the program will use the particle size entered in the window instead of a NIST particle size.



Example: enter 0.117 to use a 0.117µm particle.

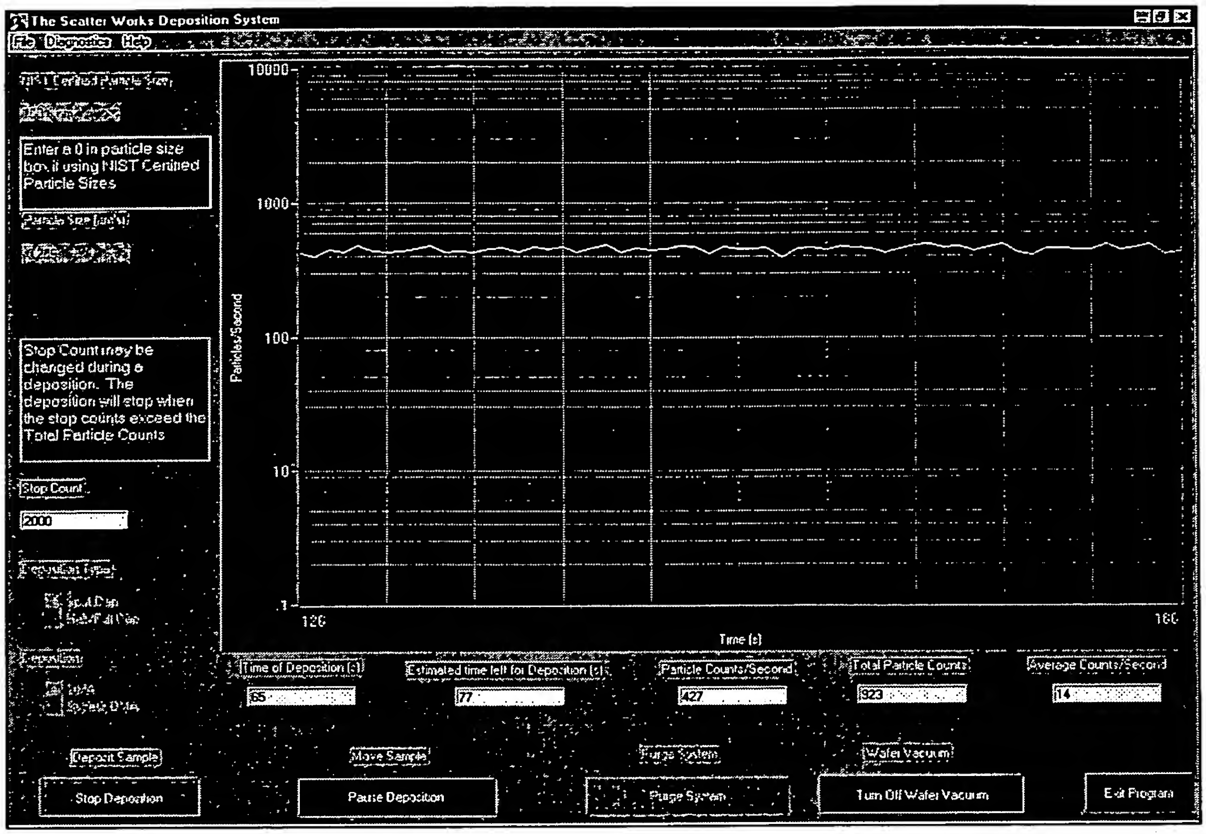
The program will automatically calculate the proper settings for the DMA (if DMA deposit switch is selected) and flow controller based upon either the NIST traceable size or the Particle size window

Stop Count – Enter the number of particles you wish to deposit in a spot or on a half or full wafer. The deposition will automatically stop when the stop count exceeds the total particle count window, which is displayed on the screen. This number can be changed at any point during a deposition.



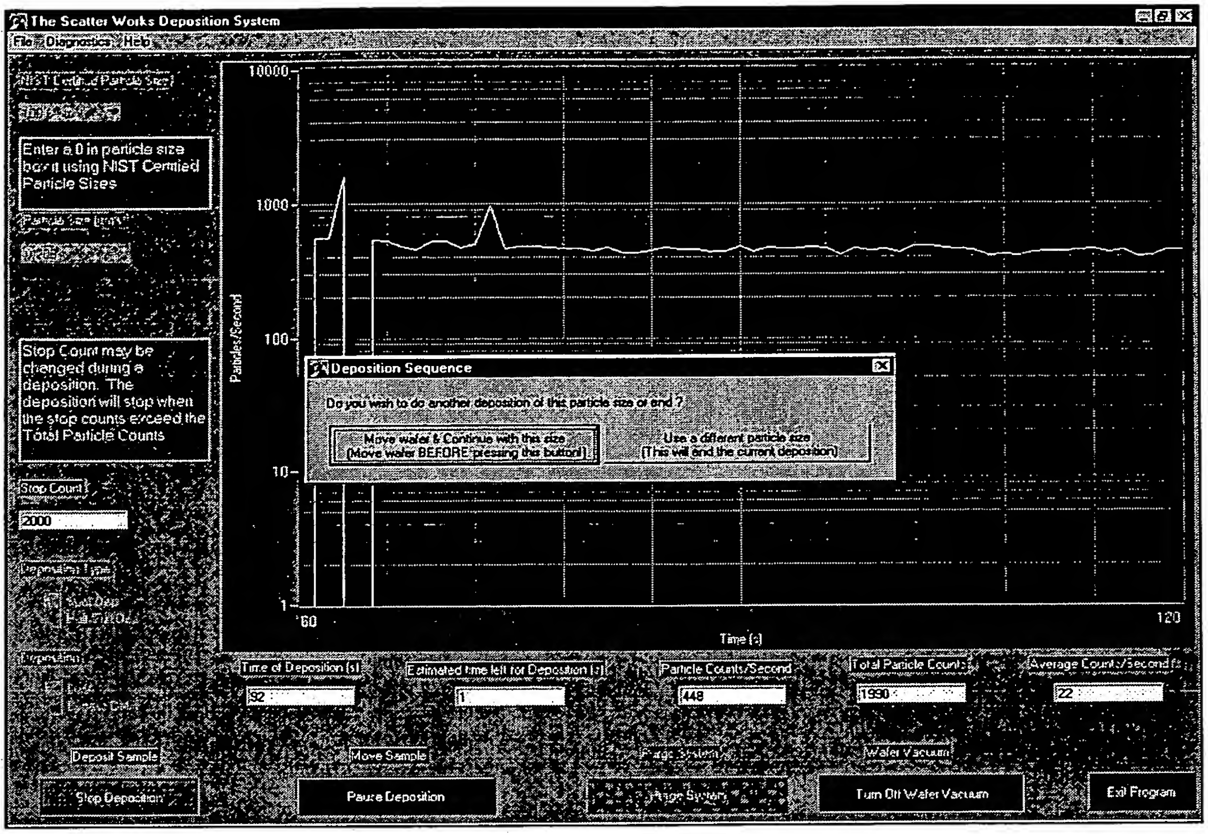
Deposit button – Pressing the deposit button will automatically use either the particle size or NIST traceable particle input and calculate the appropriate voltage and flows (if a DMA deposition). The system will allow time for the flows to stabilize and the voltage to be set. The system will automatically scan through a particle distribution and determine the center of that particle distribution. It will set that voltage and other particles that do not have that electric mobility will be stripped away and not deposited on the wafer.

The particle size, deposition type, and purge buttons are all grayed out to stop the user from inadvertently changing these settings during a deposition. The only buttons that are available to the user are the wafer vacuum (used to change to a different sample) and the pause deposition (if you want to pause the current deposition to change the stop count or for some other reason). You may also exit the program that will automatically stop the deposition sequence and exit the program.



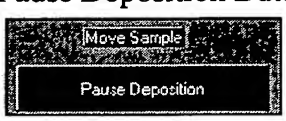
The deposition will continue until the total particle counts equal or exceed the stop count. The stop count may be changed during a deposition if the user so desires. The particle counts are graphed on the screen so that the user may monitor the particle counts. The counts will go to zero between each deposition so that the user has a visual reference where each of the depositions started.

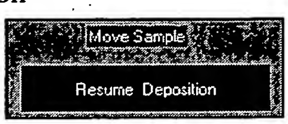
After each deposition a pop-up screen will appear that allows the user to continue doing depositions of the same particle size (useful for doing more than one wafer of the same particle size, or adding another spot deposition of the same size on the same wafer) or stopping the deposition and changing to a new particle size. It is imperative that the user moves the wafer to the new location (either in rotation or radially) or loads a new sample before continuing the deposition. If you do not move the wafer or change wafers, the system will deposit another deposition in the same spot as the previous deposition. If you press the 'Use a different particle size' button, the system will stop the current deposition. This is the same as pressing the stop deposition button.



The user may press Stop Deposition if you made a mistake or just want to cancel the deposition at any point. The system will turn off all voltages and set the flow controllers to zero flow. It is recommended that you purge the system after each deposition size to get rid of any unwanted contamination in the system.

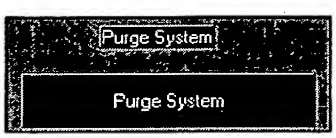
Pause Deposition Button –





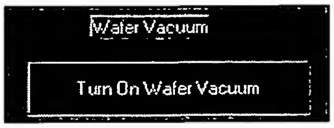
Press this button if you need more time to load a wafer want to postpone continuing the deposition. Using this feature will cause no more particles to be deposited on the sample until the button is pressed again. The total time of deposition, average count, and total particle counts will also be suspended until the deposition is resumed.

Purge System (grayed out during deposition) – This will clean the system components.



The deposition chamber does not need to be purged. If no deposition was done before pressing this button, the system uses a default setting. Pressing this button again will cause the system to stop the purge cycle. Use this option for 1-2 minutes after completing a single particle size deposition.

Turn On Wafer Vacuum -

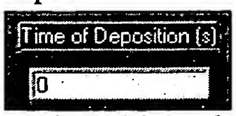


This is used for spot depositions only. It is used to apply vacuum to the sample. It is automatically turned on during a deposition and automatically shut off after the deposition is complete. This button is provided to manually turn off the vacuum for delicate materials (pellicles) or very small samples such as a 1 cm die.

Exit System -

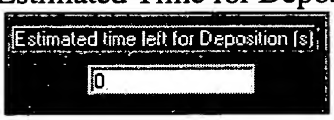
This button will exit the system software and setting all the flow controllers and voltages to zero. This button is identical to using File - Exit.

Deposition Time –



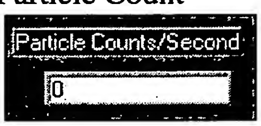
This gives the total time that the current deposition has taken. It is reset automatically for each spot and/or wafer. It is also used to count up during the initialization process that occurs before the first deposition takes place. It is reset to zero before the deposition starts.

Estimated Time for Deposition –



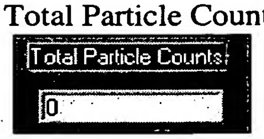
This is an estimated time until deposition completion based upon the current particle count, how many particles are currently on the wafer, and the total particles left to deposit.

Particle Count –



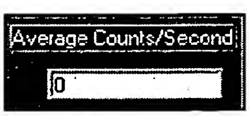
This is the current particle count that the particle counter is reading. It is also the number that is graphed to the display. The particle counter samples more particles than are actually being deposited on the wafer. This is the reason that the particle count and does not increase the total particle count at the same rate.

Total Particle Count –



This is the number of particles deposited on the sample as a function of time. When this number is equal to or greater than the stop count, the deposition is complete.

Average Particle Count –



The average particle count is the number of particles into the sample chamber divided by the total time. This is different than the average of the total particle count that is displayed on the screen.

Deposition Type (grayed out during deposition) –

This switch allows the DMA to be bypassed. Selecting 'Bypass DMA' will allow the user to deposit larger particle sizes than the DMA can process, but not in spots.

High Voltage Status–

The system has hardware interlocks to cut the power to the spot deposition platen if the door is opened. In addition, the software is constantly monitoring the voltage to the chamber, and the status is displayed on the screen to the end user. The main screen will display a green LED if no voltage is present in the chamber. It will display a red LED if there is voltage present. If the wafer drawer is opened, all power is cut to the chamber.

Mixing particles

Particles are mixed with a pipette and clean de-ionized water. Mix the solution in accordance with the table below. Discard the pipette tip after each use. Mixing is accomplished in three easy steps.

- Pour the de-ionized water in the bowl.
- Agitate the particle bottle, then use the pipette to get the indicated volume of particle solution out of the bottle.
- Put these particles in the bowl and swirl by hand.

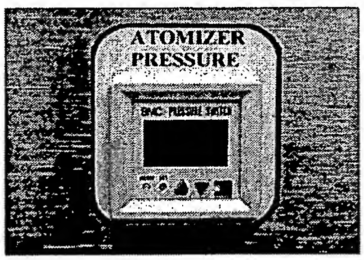
For other size particles use this chart as a guide for mixing amounts.

Particle Size (nm)	µl of particles	Water
64.6	5	1/4" in bowl
76.6	5	1/4" in bowl
87.6	5	1/4" in bowl
100.6	10	1/4" in bowl
126.4	20	1/4" in bowl
157	30	1/4" in bowl
216.5	50	1/4" in bowl
291.3	200	1/4" in bowl

Operation and Deposition Process

The deposition process is done by a few easy steps. Please refer to the sections above for software and particle mixing details.
The system should be purged free of the last particle size. To begin a new particle size:

- Mix the particles (section 3.2)
- Place the bowl on the atomizer
- Set the software setting (particle size, stop count, deposition type, and chamber select)
- Press 'Deposit'



The system will take a minute to build up pressure and stabilize the flows. During this time verify that the atomizer pressure is about 43psig. If not, stop the deposition and make sure that the bowl top is clean and make sure it is tight. After stabilization the system will begin to scan through the particle distribution. It will continue to scan through the particles until it finds the mean of the distribution peak. This process takes a little over a minute to finish. Once completed, a screen will pop-up telling the user to either move the sample (place a wafer in chamber), or exit this deposition sequence. This is the same pop up screen that you see after every deposition. It is safe to put the wafer in the chamber at any point (i.e.: before pressing deposit, during the deposition stabilization, or after the pop up screen appears.); although, it is best to leave the wafer in the cassette until needed for the deposition. You may stop the deposition at any time if you make a mistake by pressing 'Stop Deposition'. Once a deposition is complete, the screen will show the pop up menu again and you can move the wafer to a new location, change to a different wafer, or quit the deposition sequence.

Once you have completed depositing the current particle size. Let the atomizer pressure decrease to zero and remove and discard the contents in the bowl. Rinse the bowl and place the bowl back on the atomizer without solution. Press the purge button to purge the system. The system automatically sets the system to the previously used setting from the deposition. Purging takes less than a minute.